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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Fluid Couplings and Torque Converters for Industrial Equipment

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Fluid Couplings and Torque Converters For Industrial Equipment

Motorists, today, take for granted the presence of an industry younger than the majority of drivers. The application of fluid transmissions on passenger cars was introduced about ten years ago; yet their use has grown so extensively that it is predicted 90 per cent of the cars built each year will be equipped with some form of fluid transmission before another five years have passed.

Transmission of power through fluids in industrial equipment had a beginning at a somewhat earlier date. In the United States, history shows the first hydraulic transmission was built in 1901; yet mass production of such units did not begin until much later. It was not until 1932 that the American Blower Corporation started manufacture of industrial and marine type fluid couplings and a few years later, the Twin Disc Clutch Company introduced their fluid couplings and torque converters. Today, the use of fluid couplings and torque converters is a necessary part of our industrial life.

The use of fluid to transmit power is not confined to fluid couplings or torque converters. Other types available today include conventional hydraulic systems to be found on machine tools, presses, etc.; hydraulic transmissions which combine a pump and fluid motor in a closed circuit; and various mechanical devices which use oil as a means of control. All types, however, may be defined as either hydrostatic or hydrokinetic.

In hydrostatic transmissions, there is no fluid kinetic energy transfer. Velocity of fluid through the system usually is constant, whereas pressure varies. Examples of hydrostatic systems include conventional hydraulic systems, hydraulic transmissions and mechanical systems employing fluid for control purposes.

In hydrokinetic systems, pressure is more or less constant and energy is transferred by a change in the velocity of the fluid. Examples of hydrokinetic systems are fluid couplings and torque converters.

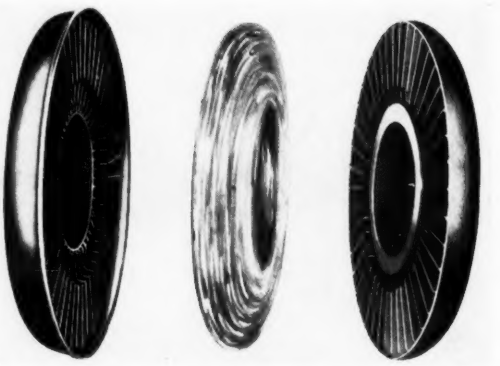
This article, the sixth of a series*, is concerned primarily with the type of fluid couplings and torque converters applied to industrial equipment; however, hydrostatic transmissions are briefly reviewed to complete the story. Previous articles in this series have been devoted entirely to automotive type fluid transmissions.

FLUID COUPLINGS

Fluid couplings, sometimes called hydraulic couplings or fluid drives, consist of three basic parts as illustrated in Figure 1—a centrifugal pump termed the impeller, a turbine or runner, and a housing. The latter, which usually rotates with the impeller, theoretically confines the oil to the working circuit. The impeller is mounted on the driving shaft (motivated by the prime mover) and the runner on the driven shaft. There is no mechanical connection between the two shafts, power from

*Lubrication, November 1946, Automotive Hydraulic Transmissions (Fluid Couplings and the Chrysler Semi-Automatic).
Lubrication, April 1947, The Hydra-Matic Transmission.
Lubrication, November 1947, Automotive Hydraulic Transmissions (The Hydrokinetic Torque Converter).
Lubrication, November 1948, Automotive Hydraulic Transmissions (The White Hydro-Torque Drive).
Lubrication, November 1949, The Buick Dynaflow Transmission.

the driving shaft being transmitted to the driven shaft by the kinetic energy in the fluid. The fluid circuit is relatively simple. The impeller acting as a centrifugal pump when rotating draws oil in at the hub and imparts to it a high velocity by the time it reaches the outer periphery. At this point, because of the shape of the impeller, oil is forced against the outer periphery of the runner causing it to rotate. Because of the positive pressure behind the oil, flow proceeds towards the hub and back through the impeller. Refinements in this simple cycle are available; as for example, a certain amount of the oil may be continuously withdrawn, cooled and replaced in the circuit to maintain low operating temperatures. Another variation involves the removal of a certain amount of oil in the circuit to give additional "slip", thus giving a variable speed control.*



Courtesy American Blower Corp.

Figure 1 — Essential parts of a fluid coupling. The impeller is on the left and the runner on the right with an oil vortex in the center. A housing, not shown, surrounds these parts. There is no mechanical connection between the impeller and runner.

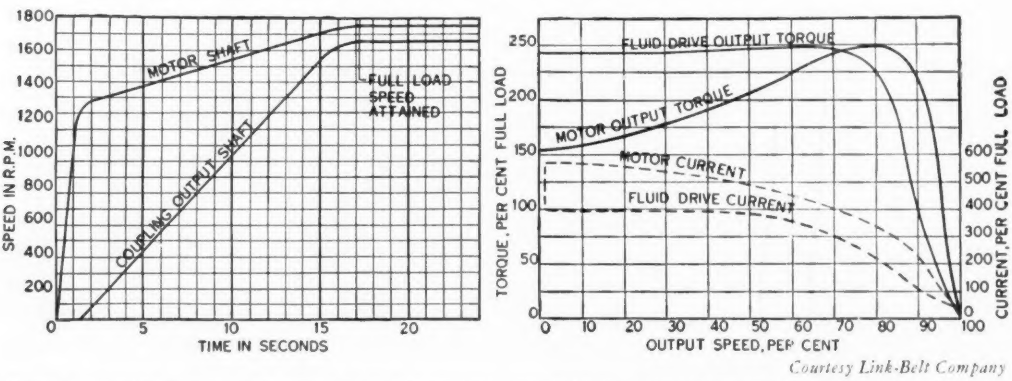
Advantages of Fluid Couplings

Fluid couplings are in effect a type of clutch. They are capable of transmitting torque but are not a torque multiplier. In fact, one of the major advantages of a fluid coupling is that output torque is invariably equal to input torque under full-speed range. The significance of this is that every electric motor and internal combustion engine has some specific speed at which it develops maximum torque. With a fluid coupling between the prime mover and the driven member, the former can be operated at its most effective speed, regardless of the speed of the coupling output shaft, thus delivering maximum torque even if the driven number is at complete standstill.

For example, consider the application of a fluid coupling to an electric motor, for which typical performance curves are shown in Figure 2. In this illustration, motor shaft speed accelerates to about 75 per cent full speed before the fluid coupling output shaft starts to turn and, at this point, nearly maximum torque is applied to the coupling output shaft. In contrast, if the electric motor were used alone, output torque on starting would be much lower. With a fluid coupling, the motor gains speed smoothly and rapidly under low torque until maximum torque is developed.

Other advantages pertaining to the use of fluid couplings in general are:

*The American Blower Corporation is the only concern manufacturing the variable speed and the constant filled types. All other concerns listed in Table I utilize the constant filled design.

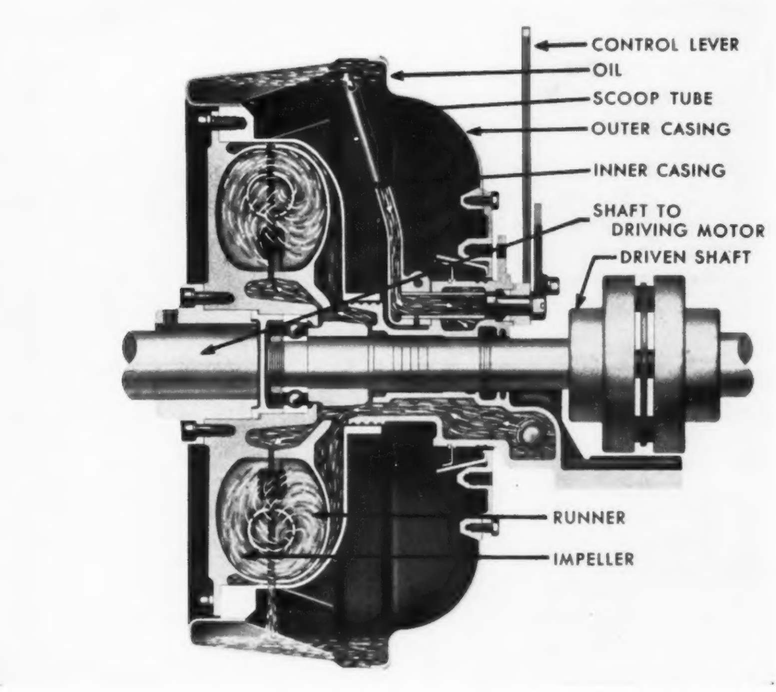


Courtesy Link-Belt Company

Figure 2 — Typical performance curves of a 3HP squirrel cage induction electric motor and a fluid coupling driving a heavy inertia load.

The curves at the left show acceleration of the motor and of a heavy inertia load typical of many driven machines. Motor attains approximately 75% full load speed before coupling circuit functions to engage the load. Motor continues to accelerate as load is automatically picked up by the coupling, until normal full load speed is attained. Difference between motor and coupling output speeds represents slip or speed drop in coupling. Time in seconds for acceleration will vary with inertia load.

Curves on the right show the relationship between output torque, current and speed, with and without the fluid coupling. Note that with the coupling nearly maximum torque starts load from zero speed, yet starting current falls almost instantaneously to a reasonable limit.



Courtesy American Blower Corp.

Figure 3 — Fluid coupling in which speed may be controlled by altering the position of the scoop tube.

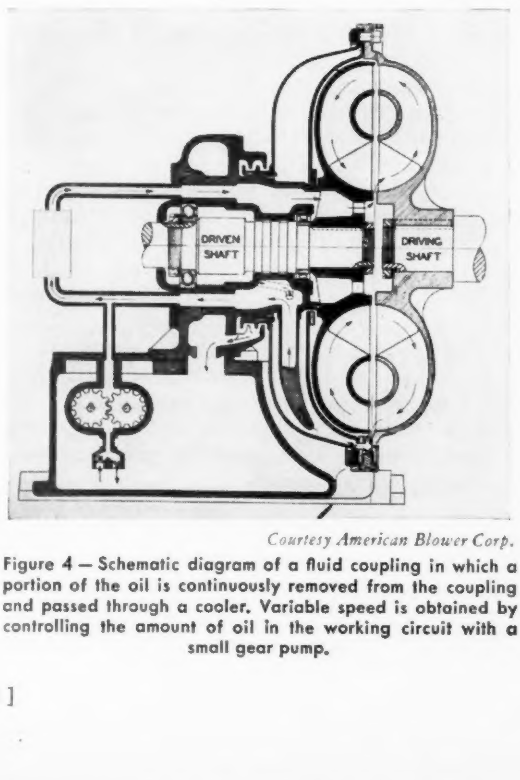
1. The prime mover cannot be stalled by application of load.
2. The cushioning effect supplied by fluid couplings protects the prime mover, intermediate gear, belt, or other drives from shock loads, excessive strain, and torsional vibration, thus increasing the service life of the equipment.
3. Need for shear pins or other protective devices is eliminated.
4. Simplified control by remote or automatic means can be accomplished.
5. The use of a smaller motor than would be necessary when starting inertia is high is often possible.

Applications of constant filled couplings include conveyors, tumbling barrels, ball mills, mixers, textile machinery, and traveling cranes.

Variations in Design

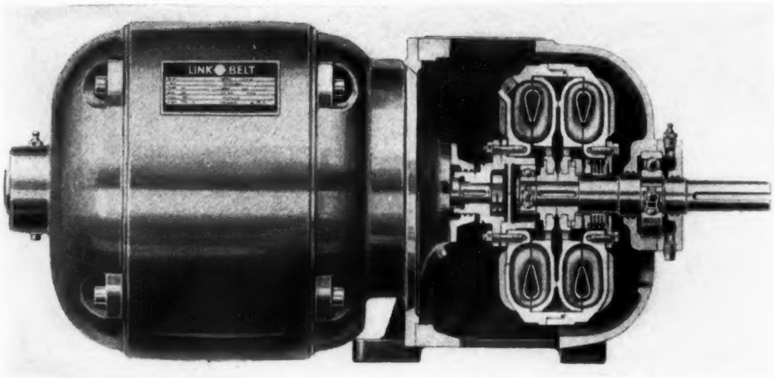
As previously mentioned, fluid couplings have been designed so that they may, in addition to the foregoing functions, be used as a variable speed control. An example of one such type is shown in Figure 3. In this design, oil travels in the conventional circuit from impeller to runner and back again. However, a portion of the oil constantly flows through calibrated nozzles in the inner casing to the outer casing. Since the outer casing rotates with the coupling input shaft, the oil is held against the outer periphery by centrifugal force. The position of the adjustable scoop tube determines the amount of oil in the outer casing, thus regulating the quantity of oil in the working circuit. If the scoop tube is fully engaged, it skims off all the oil in the outer casing, thus filling the working circuit, performance being similar to simple couplings previously described. If the tube is retracted completely so that all the oil lies idle in the outer casing, the unit is "declutched" and no power can be transmitted from the input to the output shaft. In-between positions regulate the speed or slip of the drive.

Another variation is shown in Figure 4. As in the case of the unit shown in Figure 3, this design permits a constant speed driver to be connected



Courtesy American Blower Corp.

Figure 4 — Schematic diagram of a fluid coupling in which a portion of the oil is continuously removed from the coupling and passed through a cooler. Variable speed is obtained by controlling the amount of oil in the working circuit with a small gear pump.



Courtesy Link-Belt Company

Figure 5 — Electric motor and a double fluid coupling combined as an integral unit.

through a fluid coupling to a machine required to be run at different speeds. Variable speed is obtained by controlling the amount of oil in the coupling circuit through the use of a small gear pump. This design differs from the one just described in that the position of the scoop tube is stationary. Oil taken out of the coupling circuit by the scoop tube is circulated to a cooler and back to the working circuit. There are two fluid circuits in this design and speed control is obtained by regulating the amount of oil in the primary circuit. The latter is composed of the working circuit in the coupling from which oil is removed by the scoop tube, passed through a cooler, and then returned to the coupling proper. The secondary circuit consists in pumping oil with a constant speed gear type pump from the reservoir and back again. When a reduction in speed is desired, a discharge control valve opens, permitting some of the oil to escape from the working or primary circuit to the reservoir. When speed increase is desired, an intake valve is opened, permitting additional oil to be pumped into the working circuit by the gear pump.

An alternate method is to control the quantity of oil in the coupling and, hence, the speed of the output shaft with the oil pump. In this design, the valves are omitted and the pump is rotated in one direction or another when oil is to be added to or taken away from the working circuit.

Fluid couplings of the adjustable speed type are used on a variety of equipment including mechanical draft fans, centrifugal compressors, boiler feed pumps, water circulating pumps, textile spinning frames, winding reels, calender rolls, conveyors, and many other machines.

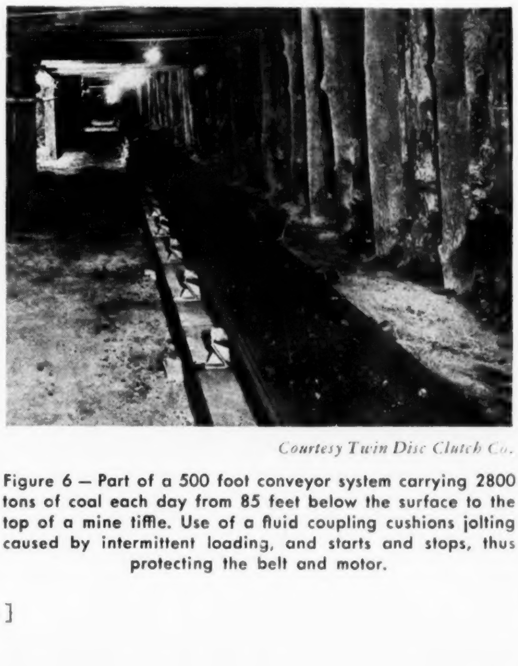
Only a slight increase in the size of a fluid coupling will give a tremendous increase in torque capacity since torque increases as the 5th power of the impeller diameter. Where overall size is critical because of space limitations, two fluid couplings in the same housing may be used as shown in Figure 5, thus permitting an approximate 12% reduction in diameter.

Lubrication

Theoretically at least, an ideal fluid for couplings would be one with practically zero viscosity and infinite specific gravity. Very low fluid viscosities permit easy flow and the higher the specific gravity the greater would be the transfer of kinetic energy from the impeller to the runner. Obviously, no such fluid exists. From a practical standpoint, petroleum oils have been found most suitable because of their availability, their lubricating qualities so necessary for allied parts such as bearings, and the fact that high overall coupling efficiencies can be obtained with such products.

As is true with all types of equipment, the choice of the most suitable viscosity for a coupling fluid is based on a compromise. As previously mentioned, the viscosity of the fluid should be as low as practical since torque transmission through the coupling is dependent upon a high circulation rate of the fluid. High viscosity lubricants may produce a viscous drag which is detrimental to efficiency. On the other hand, the viscosity must be sufficiently high to insure lubrication of bearings and related parts in the coupling.

In addition, very low viscosity fluids are pre-



Courtesy Twin Disc Clutch Co.

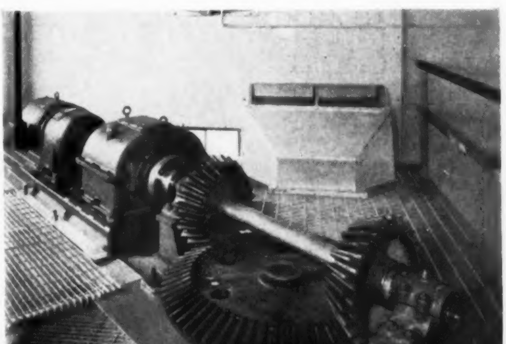
Figure 6 — Part of a 500 foot conveyor system carrying 2800 tons of coal each day from 85 feet below the surface to the top of a mine tiffle. Use of a fluid coupling cushions jolting caused by intermittent loading, and starts and stops, thus protecting the belt and motor.

TABLE I

Lubrication Instructions for Fluid Couplings as Specified by the Manufacturers Indicated

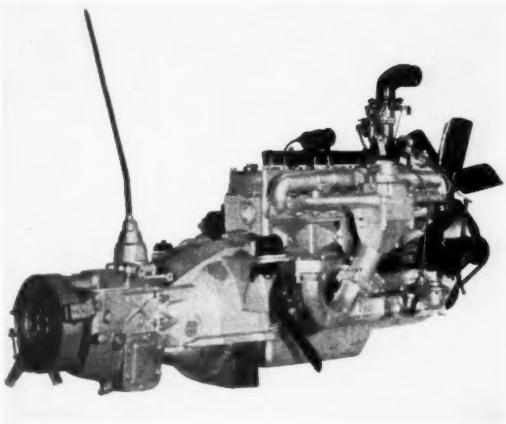
1. *American Blower Corporation*
   For all models, use a mineral oil of turbine quality having a viscosity of approximately 150 seconds, Say. Univ. at 100°F.
2. *Chrysler Corporation*
   In fluid drives on Chrysler industrial engines, use Mopar Fluid Drive Fluid, a product marketed by Chrysler.
3. *Craneveyor Corporation*
   Use a premium grade hydraulic oil inhibited against oxidation, rust and foam with a viscosity of approximately 150 seconds at 100°F., Say. Univ.
4. *Link-Belt Electrofluid Drive*
   Use light turbine or mineral oil having a viscosity of 100 to 150 seconds, Say. Univ. at 100°F.
5. *Twin Disc Clutch Company*
   A premium grade SAE 10W oil is to be used when the minimum ambient operating temperature is expected to be above minus 10°F. For minimum operating ambient temperature below minus 10°F., use SAE 5W. In these areas, SAE 5W may be used the year round.

cluded because of the desirability of low vaporization tendencies or, to put it another way, relatively high flash points. With some units under stall conditions, temperatures increase considerably and fire might be a hazard. As a result of a study of all factors involved, an oil having a viscosity of approximately 150 seconds at 100°F. S.U. is recommended for all industrial fluid couplings. Specific recommendations by manufacturers of various fluid couplings are shown in Table I. (When ambient temperatures are very low, a somewhat lower viscosity oil may be required.)



Courtesy Link-Belt Company

Figure 7 — A 20 HP Electrofluid Drive through L-B double-reduction herringbone gear and a set of bevel gears to vertical agitator shaft of a mash tub in a distillery.



Courtesy Chrysler Corp.

Figure 8 — A Chrysler 8-cylinder industrial engine equipped with Gyrol Fluid Drive, 10" clutch and 4-speed transmission.

Operating temperatures within a fluid coupling vary considerably. In addition, many couplings operate out of doors where temperatures may be quite low. For these reasons, the fluid used should show a minimum change in viscosity with changes in temperature. Experience has shown that oils having a viscosity index above approximately 80 are entirely satisfactory.

Most fluid couplings are not 100 per cent filled with oil. Therefore, the coupling in operation continually mixes the oil with air and the oil used should be capable of readily freeing itself of air. For this reason, oils which will suppress foaming are recommended.

Slippage produced in a coupling as a result of heavy loads results in heat formation which must be dissipated through the oil to the outer casing, or through a cooler if the unit is so equipped. As the temperature increases, so will the oxidation rate of the oil. Cheap insurance is obtained through the use of an oxidation inhibited oil since oil, if it becomes oxidized, can seriously impair operating efficiency and can even result in serious damage to the coupling through corrosion and varnish or sludge deposits.

As shown in accompanying illustrations, many fluid couplings are operated in exposed locations such as on construction, farming and drilling equipment. In such installations, it is necessary that internal parts of the coupling be protected against rusting. Even units located indoors can rust as a result of moisture from condensation. Additives

incorporated in the oil to prevent rusting are very beneficial for they will prevent rust formation under all operating conditions.

Summing up, the type of oil recommended for use in fluid couplings should have a viscosity of approximately 150 seconds, Say. Univ. at 100°F., a viscosity index above 80, be non-foaming, rust-inhibited, and oxidation stable. Such a product will insure long, trouble-free service and will permit couplings to operate at maximum efficiency.

Maintenance

Maintenance of fluid couplings is relatively simple since little can go wrong. In so far as the oil is concerned, the following suggestions are made:

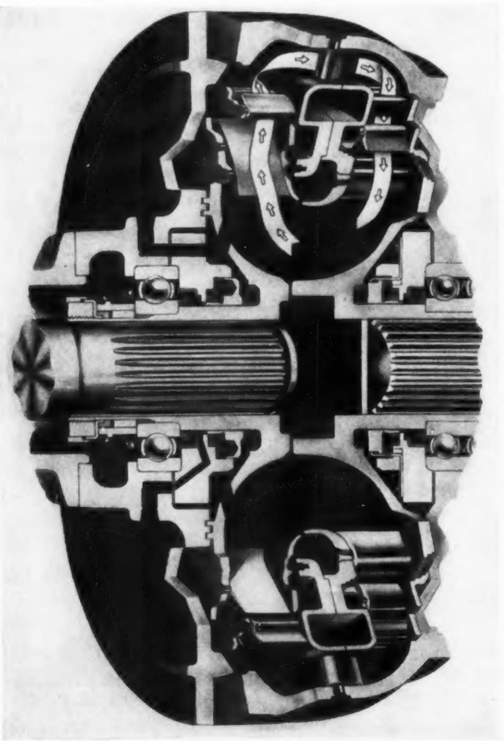
1. Before checking the fluid level in the coupling, allow the unit to cool to room temperature.
2. When filling units or adding make-up oil, follow the procedure outlined by the manufacturer and check the level at intervals prescribed by him.
3. Loss of fluid from the unit will be evidenced by excessive slip.

TORQUE CONVERTERS

Whereas fluid couplings are in reality a clutch, torque converters serve as both a clutch and a transmission. The reasons for the phenomenal growth of torque converters in industry are that, first, they offer a means of multiplying up to 5-6 times the starting torque of an engine and, second, they provide a stepless transmission which is completely automatic in nature.

It is well known that all internal combustion engines have lower starting torques and are less efficient at starting speeds than at higher speeds. For years engineers have searched for a method of increasing the starting torque of these engines. The standard gear transmission has been one solution, and a good one, except that it must be shifted between a series of fixed ratios. The advent of the torque converter, however, has resulted in a method of supplying high initial torques and, in addition, furnishes a stepless automatic transmission which does not require gear shifting or other mechanical or manual control.

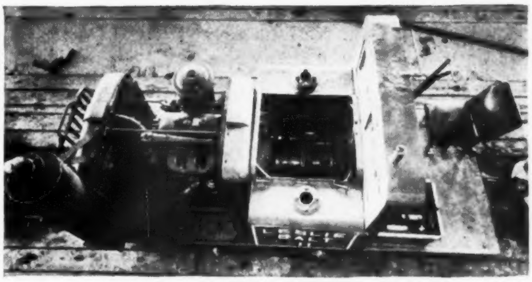
Torque converters differ from fluid couplings in that reaction blades are inserted after one or more runners, thus giving a unit which is capable of absorbing more kinetic energy from the fluid. Actually, torque converters consist of an impeller, the balance of the unit resembling a compact steam turbine. Converters may consist of a multiple number of stages, each stage being composed of a set of stationary reaction blades and a corresponding set of turbine blades on the runner or output shaft. All converters on the market today consist of from one to three stages. Each type has its own individual advantages.



Courtesy Twin Disc Clutch Co.

Figure 9 — A cutaway view of the Twin Disc torque converter is shown at the extreme left. Shown are pictures of the impeller at the top left, the turbine at the top right and the housing, containing the reaction blading bottom left.

The presence of the reactor blades is the basic reason for the torque converter's unique ability to multiply its input torque by as much as 5-6 times. Unlike the coupling but like the steam turbine, the blading of the torque converter is accurately machined all over to a highly developed air foil or streamline cross section having a high surface finish. The number, shape, dimensions, and angle



Courtesy Detroit Diesel Engine Div., General Motors Corp.

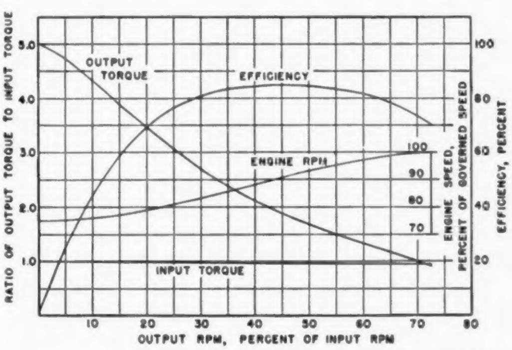
Figure 10 — This Vulcan locomotive powered by a GM Diesel engine — torque converter unit hauls a 90 ton load with ease.

of these blades all have a pronounced effect on the performance of the converter and are the primary factors used by the transmission engineer in coordinating the converter with the characteristics of the engine to be associated with it.

Like the fluid coupling, there is no mechanical connection between the converter input and output shaft. Engine power is first converted to kinetic energy in a stream of fluid, and then converted back to mechanical energy at the converter output shaft.

Torque converters are used on a wide variety of equipment, including tractors, oil field equipment, logging winches and yarders, construction machinery, rail cars and railway locomotives. To date, prime movers include only gasoline and Diesel engines.

Torque converters, like fluid couplings, are available in a variety of modifications but, in general, all fall within two general classifications. The first is a true fluid torque converter whereas the second is a modification which incorporates, in effect, a fluid coupling, thus combining in one unit the advantages of each. Both types of torque converters are discussed briefly in ensuing paragraphs.

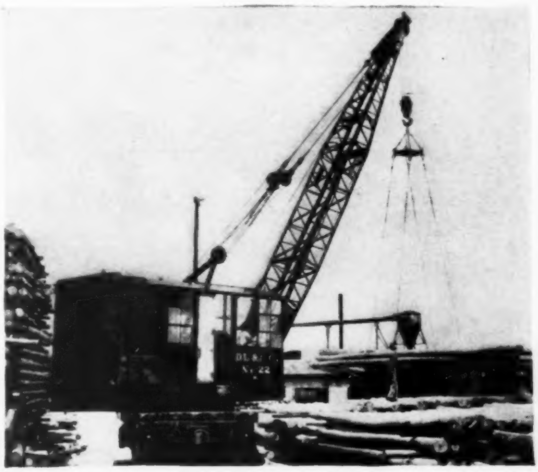


Courtesy Twin Disc Clutch Co.

Figure 11 — Typical performance characteristics of a Twin Disc Hydraulic torque converter. Maximum efficiency is obtained when the output speed is one-third to two-thirds of input. Observe that torque multiplication diminishes as output speed approaches that of input speed.

Twin Disc Type

The Twin Disc design of torque converter is a three-stage unit. A typical design is shown in Figure 9. In this converter, the fluid leaving the impeller strikes the first set of turbine blades, imparting some of its kinetic energy to the driven shaft. The fluid then passes through stationary reaction or guide blades which change the direction of flow so that the fluid enters the second set of reaction blades at the proper angle. After passing through reaction blades, the fluid flow is changed by a second set of stationary guide blades before entering the third set of turbine blades. Upon leaving the latter, the fluid is directed back to the impeller inlet and the cycle repeated. Kinetic energy placed in the fluid by the impeller is given up in part to each of the turbine blades. With such a unit, it is usual to obtain initial torques of 5 and 6 times that of the prime mover.



Courtesy Twin Disc Clutch Co.

Figure 12 — Diesel powered crane equipped with a torque converter.

Typical performance curves for a three-stage torque converter are shown in Figure 11. Note that overall efficiency is high over a wide range but drops off rapidly at both ends of the scale. For this reason, torque converters are engineered carefully to specific applications so that the torque converter will normally operate in the range of high efficiency. Attention is also called to the fact that torque output is highest under stall conditions and that it falls off as output speed approaches input speed. The point at which the rates of input torque and output torque are exactly 1.0 is termed the "Clutch Point". Beyond this point, both the output torque and the efficiency drop off to low values.

General Motors[1] and Torcon[2] Designs

Torque converters of the type just described are inefficient above the clutch point. Fluid couplings on the other hand, are highly efficient in transmitting torque whenever the output-input shaft speed ratio approaches 1. Thus, these two units complement each other; i.e., one is most capable when the other is least. If the two units could be combined in some way, the deficiencies of each would be overcome. Essentially, this is what has been done in the General Motors and Torcon types of torque converter.

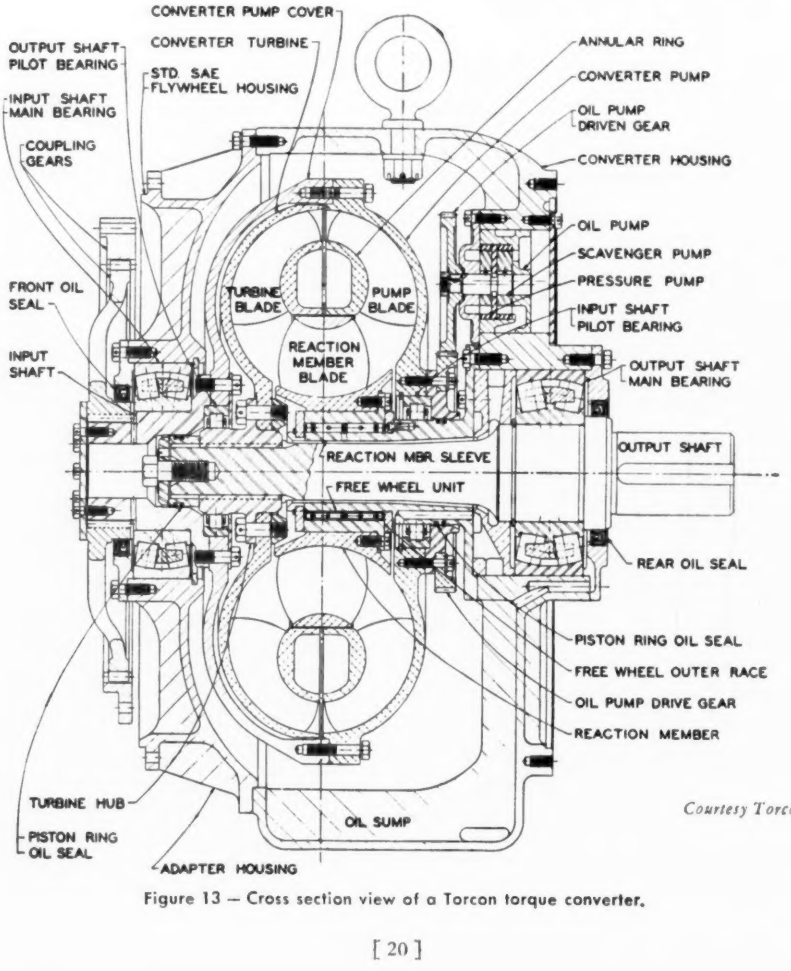
A typical example which is actually a single-stage torque converter is shown in Figure 13. In this design, the inner housing and pump blade (impeller) are attached to the driving hub on the input shaft and are driven always at motor input speed. Fluid leaving the impeller pump passes on to the turbine blades. Upon leaving the latter, the oil passes through a stationary reaction member which changes the direction of the oil and gives impetus to the pump or impeller. In effect, the reaction member acts as a fulcrum, resulting in torque increase. This design is capable of increasing starting torques up to 3 times.

So long as the output torque requirements exceed the input torque, the reaction member is stationary and the unit functions as a torque converter. However, when the output torque requirements reach the input torque (the clutch point), the reaction member automatically releases itself and is free to rotate. When the reaction member rotates, the unit performs as a fluid coupling.

Included in this design are two small gear pumps shown at the right which are used to circulate the oil through the unit. One is a pressure pump which maintains fluid under pressure to the working circuit, drawing oil from an oil reservoir. The second is a scavenger pump used to collect oil from the sump and return it to the reservoir.

A typical performance curve is shown in Figure 14. Note that at the clutch point the torque ratio has dropped off considerably and that the overall efficiency has just begun to drop. When the re-

[1]Allison Division of General Motors Corporation (Industrial Type)
[2]Torcon Corporation



Courtesy Torcon Corp.

Figure 13 — Cross section view of a Torcon torque converter.

action member free wheels, as it does when the unit operates as a coupling, efficiency goes up and torque ratio remains almost constant.

Lubrication

It is essential that the oil used in torque converters shall not oxidize or deteriorate. Because of the severe operating conditions imposed on the oil, it has been found that oils containing inhibitors to enhance needed properties are most suitable. Desirable properties in torque converter fluids are as follows:

Oxidation Stability: This is of prime importance since operating temperatures are often quite high and oil oxidation products, such as varnish or sludge, can be very harmful to the unit. Oils containing oxidation inhibitors proven in service to be effective are recommended.

Foam Prevention: The formation of foam in the system can cause erratic operation of the converter. It is essential that the oil used be highly resistant to foaming.

Rusting: Oils containing rust inhibitors are recommended since small amounts of rust can do considerable damage to precision-made parts.

Pour Point: The pour point should be below the lowest anticipated ambient temperature.

Effect on Seals: The fluid must not affect seals adversely.

Viscosity Index: The fluid should have as high a viscosity index as practical so that changes in operating temperatures will have a minimum effect on viscosity.

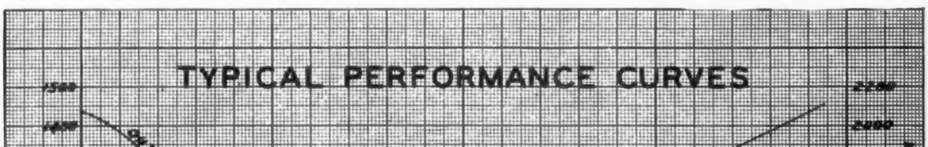
Viscosity: The viscosities of fluids recommended for specific torque converters are shown in Table II. Normally, a very low viscosity product is used if the fluid is not required to lubricate bearings or other miscellaneous parts. In cases where antifriction bearings are contained in the converter housing, a somewhat high viscosity is recommended.

Flash Point: In order to prevent the possibility of fire when units are operated under stall conditions for a period of time, the flash point of the fluid should be above approximately 175°F.

Summing up, fluids having excellent oxidation, foaming and rusting resistance, and having the viscosities indicated in Table II, are recommended for torque converters used on industrial type equipment.

Maintenance

Torque converters, like fluid couplings are relatively free of maintenance problems. Both are de-



Courtesy Torcon Corp.

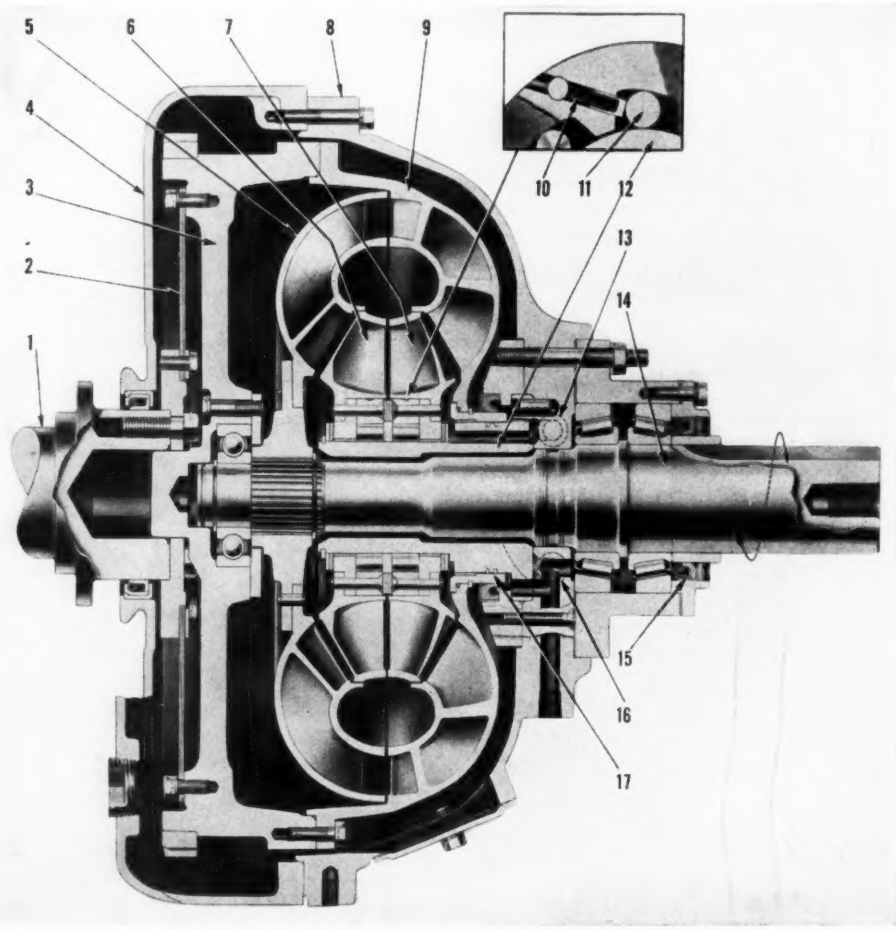
Figure 14 — Typical performance curves of a Torcon torque converter. This unit operates as a fluid coupling above the clutch point (the latter being the point where the ratio of output torque to engine torque reaches one).

signed and manufactured to give long, trouble-free service. As is true wherever petroleum products are used, unless a few simple rules are followed, trouble may be encountered. In order to obtain uninterrupted service in torque converters, the following suggestions are made:

1. Use an acceptable quality of oil of the correct viscosity.
2. Change the oil at intervals prescribed by the manufacturer.
3. If oil filters are used, change these before they become badly clogged.
4. Maintain prescribed oil pressure at all times to prevent malfunctioning of the unit and possible cavitation on the blading.
5. Be sure operating oil temperatures do not exceed those specified by the manufacturer.

HYDROSTATIC FLUID TRANSMISSIONS

It will be remembered that in hydrokinetic drives energy is transmitted by fluid velocity whereas in hydrostatic drives energy is transmitted by fluid pressure. Many hydrostatic type drives are available, most variations being composed of a hydraulic type pump (gear, piston, or vane), and a similar fluid motor usually combined in one housing. Component parts of such hydrostatic drives and the type of fluid required have been discussed in a



Courtesy Allison Div., General Motors Corp.

Figure 15 — Cutaway view of new General Motors Industrial Torque Converter.

1. Engine Crankshaft
2. Flexplate
3. Flywheel Assembly
4. Flywheel Housing
5. Converter Turbine
6. First Stator
7. Second Stator
8. Converter Housing
9. Converter Pump
10. Roller Spring
11. Freewheel Roller
12. Converter Ground Sleeve
13. Oil Supply Inlet (New)
14. Converter Output Shaft
15. Outer Lip Type Seal
16. Outlet to Oil Supply Tank
17. Piston Ring Type High-Pressure Oil Seal

TABLE II

Lubrication Instructions for Torque Converters as Specified by the Manufacturer Indicated

1. *General Motors Corporation Industrial Type*
   Above −10°F. use SAE 10 Heavy Duty lubricating oil identical in quality to oil specified for General Motors Series 71 Diesel Engines.
2. *Torcon Corporation*
   For all models use a light hydraulic oil.
3. *Twin Disc Clutch Company*
   The fluid used should meet the following specifications:

	For Older Models (Model Nos. 10012 and down, also Nos. 11519 and down)	*For Newer Models (Model Nos. 10015 and up, also Nos. 11522 and up and 16002 and up)*
API Gravity at 60°F.	—	36.0-40.0
Flash, °F., Min.	175	175
Fire °F., Min.	200	200
Viscosity-Centistokes at 100°F.	8.0-10.0	2.5-3.5
Viscosity-Say. Univ. 100°F.	52.0-58.8	34.4-37.6
Color-Dyed (optional)	Red	Red
Pour, °F., Min.	−40	−40
Aniline Point, °F., Min.	170	170
Initial Boiling Point, °F., Min.	390	390

Bearings require a soft, non-fibrous grease of a type suitable for ball and roller bearings operating at 200°F.

previous issue of magazine, LUBRICATION*. For this reason, they are not included in the present article.

Thomas VariDRAULIC Drive

Another basic type of hydrostatic drive, manufactured by Thomas Hydraulic Speed Controls, Inc., is shown in Figure 17. Essentially this unit, known as the VariDRAULIC Drive, consists of three planetary gears and a sun gear. This drive is similar to a fluid coupling in that it will transmit torque 100 percent but not multiply torque; also it can be used as a speed reducer and is capable of exerting maximum torque at the most efficient driving member speed.

This drive is relatively simple in design. It is essentially a mechanical drive of the planetary type but controlled hydraulically to obtain maximum efficiency. As can be seen from Figure 17, the casing is attached to the input shaft (A). The three planetary gears (B), carried by the casing, in turn drive the sun gear (C) which is mounted on the output shaft (D). If no resistance is placed between the sun and planetary gears theoretically at least, the outer casing would revolve at input speed and no torque would be transmitted to the output shaft with the result the latter would be stationary. On the other hand, if a steel bar for example, were inserted between the sun and planetary gears, all gears would be locked and the output shaft speed would equal input shaft speed.

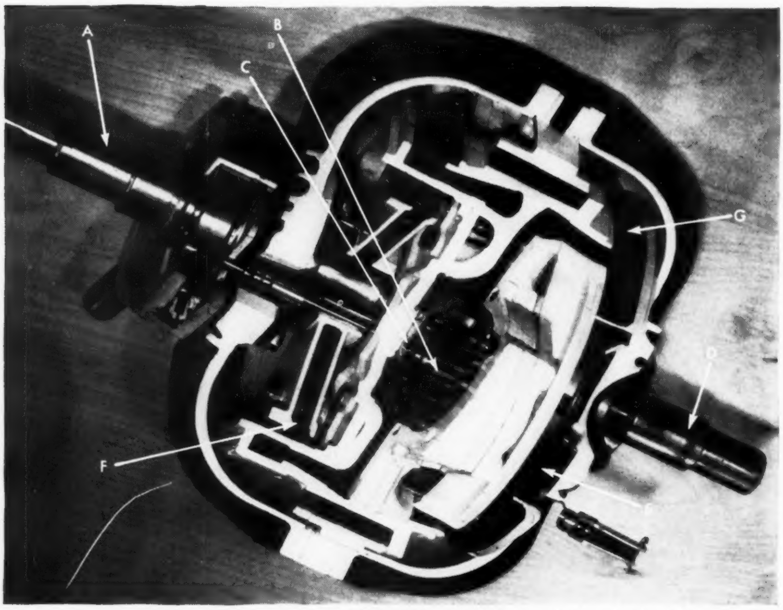
Courtesy Thomas Hydraulic Speed Controls Inc.

Figure 16—One application of the Thomas VariDRAULIC Drive.

Control of speed and torque between these two extremes is obtained hydraulically, for in this design a fluid is in effect substituted for the steel bar mentioned above. The unit is not completely filled with oil, therefore, as the casing rotates the oil is thrown by centrifugal force to the outside and the shaft is surrounded by air.

To illustrate how variable speed and torque control is obtained, first consider operation of this unit under conditions which produce no torque on the output shaft (maximum slip). Air is drawn in through the circular valve (E) from a point adjacent to the shaft and is ported between the three planetary gears and a sun gear functioning as three gear pumps. Air then passes on out through a second valve (F). Under such conditions there is no resistance to the movement of the various gears and no torque is transmitted. (Incidentally, there is enough oil mist in the air at all times to adequately lubricate the gears.) Full power-transmitting operations result when circular valve (E) is shifted so that oil from the casing is drawn into the pump ports through special openings at point

*Lubrication, August 1946; Hydraulic Oils for Industrial Equipment.



Courtesy Thomas Hydraulic Speed Controls Inc.

Figure 17 — Cutaway view of the Thomas VariDRAULIC Drive.

(G) thus supplying a solid column of oil to the gear pumps (between the sun and three planetary gears). Since valve (F) is closed under these conditions the oil cannot pass through the gear pumps with the result that the planetary and sun gears are interlocked and prevented from relative rotation. Thus in effect, a mechanical drive is obtained with the input shaft driving the output shaft through the casing, planetary and sun gears. (Due to a small oil leakage through the gears there occurs a slight slip.) Since the positions of valves (E) and (F) are controlled externally during the rotation of the casing, any position between the two extremes mentioned above may be obtained thus affording infinite speed and torque variations.

The drive just described is being used extensively on agricultural, trench digging machines, and construction machinery and has many other fields of application. It may be coupled with electric motors, and gasoline or Diesel engines.

Lubrication of VariDRAULIC Drive

This unit requires the use of a fully inhibited type hydraulic oil meeting the specifications shown in Table III.

The oil should be extremely resistant to oxidation since operating temperatures may reach 250°F. under slip-torque transmitting conditions. Obviously, also, the oil should not foam since maximum efficiency can only be obtained with an oil which readily separates from air.

Since most of these units are used out-of-doors a rust inhibited oil is most desirable.

TABLE III

Specification of Fluid to be Used in Thomas VariDRAULIC Drives:

Viscosity, Say. Univ. @ 100°F.	300-325
Viscosity Index	90 Min.
ASTM Oxidation Test (Hours to 2.0 Neut. No.)	1500 Min.
ASTM Rusting Test	Pass
CRC Foam Test	Pass

CONCLUSION

The use of fluids to transmit power is a vast and rapidly expanding field. Primary reasons for this include ease of control, elimination of shock loads or overloading, economy in design and operation, ease of maintenance and reduced operator fatigue.

Fluid couplings and torque converters have all the foregoing advantages and many more. The use of such units on industrial equipment is well established and will continue to grow.

The petroleum industry has developed special oils for fluid power transmitting units. Their use is cheap insurance against sludge, varnish, rust or foam formation. Such oils are strongly recommended if malfunctioning and maintenance costs are to be minimized or eliminated.

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INDUSTRIAL FLUID COUPLINGS

American Blower Corporation	Texaco Regal Oil A (R&O)
Chrysler Corporation	Mopar Fluid Drive Fluid (available only from Chrysler Corp.)
Craneveyor Corporation	Texaco Regal Oil AZ (R&O)
Link-Belt Electrofluid Drive	Texaco Regal Oil A (R&O)
Twin Disc Clutch Company	
Above −10°F	Texaco Regal Oil AZ (R&O) (or Regal Oil A (R&O) above 25°F)
Below −10°F	Texaco Torque Fluid

INDUSTRIAL TORQUE CONVERTERS

Allison Div. General Motors Corp.	Texaco Ursa Oil X-10★★ or Texaco D303 Motor Oil SAE 10
Torcon Corporation	Texaco Ursa Oil X-20★★ Texaco D303 Motor Oil SAE 20 or Havoline Motor Oil SAE 20
Twin Disc Clutch Company	
All models	Texaco Torque Fluid

INDUSTRIAL HYDROSTATIC DRIVE

Thomas Hydraulic Speed Controls, Inc.	
VariDRAULIC Drive	Texaco Regal Oil PC (R&O)

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